Particulate Matter Emissions from Sydney Railway System: Concentration, Heavy Metal Content and Implications for Public Health

By

Marwa F Mohsen

Thesis submitted for the degree of Master of Engineering (Research) for the University of Technology Sydney

October 2017

I hereby declare that this thesis has not been submitted, either in the same form or a different form, to UTS or any other university for the award of any other degree. To the best of my knowledge and belief, the thesis contains no material that has been previously published or written by another person except where references are made.

This research is supported by an Australian Government Research Training Program Scholarship.

Marwa F Mohsen

Acknowledgements

To my life candles, my kids Yousif and Yousur: because I owe it all to you. Many thanks for everything!

This thesis would not have been possible without the support of many people. First and foremost, I would like to thank my principal supervisor Professor John Zhou for his invaluable support, knowledge and commitment. Special thanks to my former co-supervisor Ken Halstead for his support and knowledge.

I am grateful to my family and friends for their unconditional love, support, patience and trust; in particular for my great parents, my lovely husband, sisters and friends.

I am also grateful for the support and encouragement from my colleagues over the last two years, who made my study journey as enjoyable as it has been. In particular I would like to thank Ahmed Al-Zubaidy, Mohammad Boshir, Zohreh Salari and Arati Pokhrel.

Special thanks to Sydney Trains and their staff for providing great guidance and support during the data collection period of time. Exceptional thanks to the University of Technology Sydney for giving me this opportunity to do my research and to use all the available laboratories and resources.

Table of Contents

List of Figures

List of Tables

Abstract

Studies have shown that commuters can be exposed to substantial amounts of particulate matter (PM) during commuting time using the railway networks with major implications to public health. According to the Bureau of Transport statistics, Sydney Trains run about 1 million customer journeys per weekday in Sydney commuting people to different destinations. This thesis focuses on the PM assessment in the Sydney railway system at different railway microenvironments including measurements from the train carriages and the platforms at underground and ground levels.

First the thesis focuses on PM_{10} and $PM_{2.5}$ measurements taken from four different microenvironments and two fixed air quality stations during seven weeks of sampling (September to November 2015). Results indicate that average underground PM_{10} and $PM_{2.5}$ concentrations from inside the trains were 2.8 and 2.5 times greater than the ground level measurements. Similarly, PM_{10} and $PM_{2.5}$ concentrations on the underground platforms were 2.7 and 2.5 times greater than at ground level platforms. Average underground PM levels have exceeded the national limits during the sampling period. Correlation analysis showed a strong to moderate association between ambient background and ground level PM (r^2, 0.952 - 0.50) and weak association with the underground concentrations with a maximum r^2 of 0.264. It was also found that Sydney railway can be considered as one of the cleanest systems in comparison with different railway systems globally.

Then the thesis focuses on the metal content in the railway-derived PM. Another sampling campaign was conducted to collect the dust samples needed for the metal analysis. Samples were collected from five railway microenvironments (underground platforms) and also from an urban park for comparison purposes. The USEPA 3050B method was employed to extract the dust samples and to prepare them for metal analysis. Using the

Microwave Plasma - Atomic Emission Spectroscopy (MP-AES), the concentrations of twelve metals were detected. Based on the pollution index (PI), integrated pollution index (IPI) and enrichment factor (EF) analyses, the metals content in the railway PM indicated high levels of pollution from anthropogenic sources mainly attributed to local railway sources. Fe was the most enriched element with an EF value of 61.3, and PI and IPI values of more than 9. After Fe, the EF values for the other metals followed the order of Ni, Cr, Mn, Ba, Zn, Cu. Consistent with previous studies, the current results indicate that high metal content in the railway PM is mainly attributed to local railway sources such as the wear and abrasion processes.

The last part focuses on the potential health risks based on the metal content. Three probabilistic risk assessments approaches have been applied in this chapter: average daily dose method for non-carcinogenic effect, dose effect method for the carcinogenic effect and qualitative risk assessment. Results indicate that no potential risks to cause non-carcinogenic effects from any metal can occur at the measured concentrations except a very low indication from Cr levels. A carcinogenic effect was only performed for Ni and Cr indicating no potential cancer risks based on the measured concentrations. Finally, a qualitative risk assessment was employed to overcome the problem of the scarce information needed for estimating the potential cancer risk for the rest of elements using the ISO31000 method. The results also indicate low to moderate potential carcinogenic risks from Zn, Fe, Mn, Ba and Cu.

Finally, the limitations of this study have been stated with some recommendations for future studies and applications which might help in reducing the PM levels at the railway networks.